Prof. Meinardus's scheme[2] also includes a series of cyclones traveling from west to east over the southern ocean; but he gives strong reasons against the presence of an anticyclone over Antarctica. His chief objection to such an anticyclone is that anticyclonic conditions are accompanied by an excess of evaporation over precipitation: hence it would be impossible to account for the excess of precipitation which gives rise to the large glaciers and snowfields discharging the known large quantities of ice.

2. The simultaneous observations made at Cape Evans, Cape Adare, and Framheim were then considered to investigate the processes which are at work in the Ross Sea area. The chief conclusions were: The high southeasterly winds—commonly called blizzards [in the literature of Antarctica]—are not caused by cyclones passing into Ross Sea, but are the result of the large differences of temperature which exist in the lower atmosphere over the Barrier and Ross Sea. The cloud observations show that

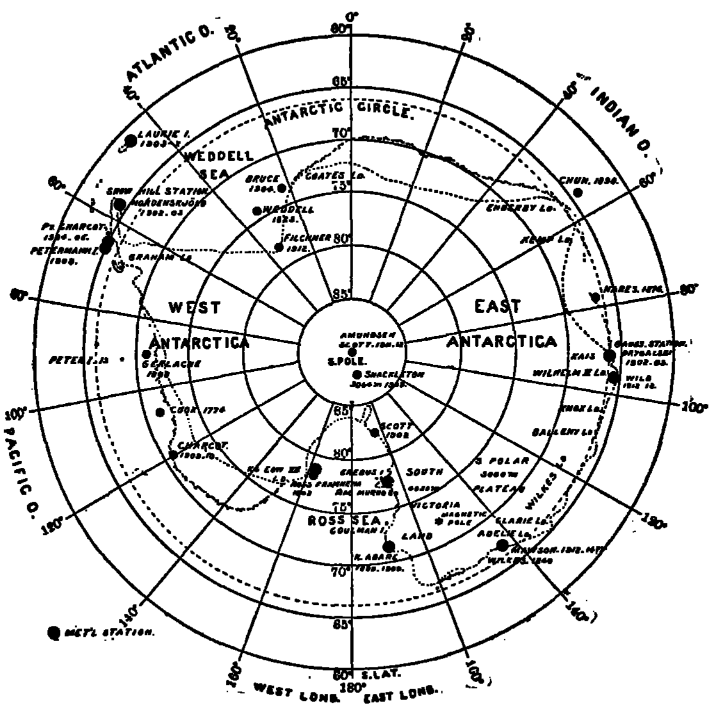

FIG. 1.—Location of meteorological stations within the South Polar Regions.

air feeds into the Antarctic at high levels and passes north again in the "blizzards." Meinardus's objection that in such a circulation precipitation would not exceed evaporation was shown not to hold, because of the great cooling of the air due to radiation. The air while sinking loses so much heat by radiation that, when forcibly made to rise again in the "blizzards," saturation is reached at a much lower level than that at which the air entered. Thus anticyclonic conditions are consistent with an excess of precipitation.

3. The existence of a belt of cyclones between Antarctica and Australia was then considered. Curves showing barometer and wind observations at the *Gauss* winter quarters were shown. From them it was seen that during the passage of deep waves of pressure there is practically no variation of the wind direction at that station. In most cases the wind blows a gale from the east both while the barometer falls rapidly and while it makes an equally rapid recovery. At present it appears quite impossible to reconcile the wind and barometer observations with any system of circulation of wind about a center of low pressure moving from the west to the east. Further, the simultaneous barometer observations at Melbourne, The Bluff, New Zealand, and at Cape Adare were examined without finding any certain indication of the same cyclone affecting the northern and the southern stations.

4. The monthly departures from the pressure normals at Cape Evans were compared with corresponding values for stations in Australasia, and an important negative correlation was found.

5. The importance of a permanent meteorological station on Antarctica was urged.

LOW TEMPERATURE OF THE SOUTHERN HEMISPHERE.[1]

While discussing at the Australian meeting of the British Association for the Advancement of Science certain other physical features of Antarctica, Dr. G. C. Simpson made the following comments on the cause of the relative difference in temperature between the Northern and Southern Hemispheres:

"I think we do not sufficiently realize that the Southern Hemisphere is much colder than the Northern Hemiphere, and the reason for this difference is certainly not understood by scientists. When we think of the temperature of a place we think of the temperature in the lower atmosphere. Now, the mere passage of light through the atmosphere will not warm it. The main method by which the atmosphere becomes warmed up is by the sun shining on something it can warm. Now, in the Northern Hemisphere there are large masses of land which can absorb the sun's energy, and then give the heat to the atmosphere. In the Southern Hemisphere, on the contrary, the whole mass of land within the Antarctic Continent [Antarctica] is covered with ice, which is practically a perfect reflector, and therefore when the sun shines on it a large proportion of the energy is reflected into space. I think scientists have not quite realized how important that is—that 5,000,000 square miles of the earth's surface in the Southern Hemisphere reflect into space a large part of the energy received from the sun. I feel certain that this is one of the chief reasons for the difference in temperature between the Northern and Southern Hemispheres."

AUSTRALIAN RAINFALL.[2]

By H. A. HUNT, Commonwealth Meteorologist.

The main factors to be considered in relation to the controlling causes of rainfall in Australia are the southeast and westerly trade winds, the monsoonal and southern depressions, cyclones from the northeast and northwest Tropics, locally formed cyclones, and the anticyclones, in conjunction with the modifying effects on these various atmospheric movements of the physical features of the different parts of the country.

Around the central dry area of Australia the isohyets describe somewhat concentric curves, the modifications being mostly due to variations in elevation. Thus the Darling Ranges to a great degree account for the rainfall of the southwest corner of the continent. The Flinders

[2] See this REVIEW, April, 1914, 42: 223-230.—C. A., jr.

[1] *Reprinted from* Report of the Eighty-fourth Meeting of the British Association for the Advancement of Science. London, 1915, p. 417.

[2] *Reprinted from* Report of the Eighty-fourth Meeting of the British Association for the Advancement of Science, Australia, 1914. London, 1915, p. 439-442.

Range, South Australia, and the Australian Alps, in the southeast, have a heavier rainfall than the surrounding tracts, owing to their cooling effect on the air currents. Along the eastern elevated margin of the Commonwealth the ridges between large river valleys also account for an enhanced precipitation. Examples of the latter type are the Peak Range and the Darling Downs in Queensland, where the eastern ranges of the northern parts of that State obstruct the southeast trade winds and cause our heaviest rainfall. In western Tasmania there is an excessive rainfall for similar reasons, though there the westerly trades are the moisture-laden winds.

During the hotter months, November to April inclusive, the northern parts of Australia are wet and the southern dry; in the colder months, May to October inclusive, the southern parts are wet and the northern dry; while over the eastern areas of the continent the rainfall is distributed fairly generally throughout the year.

The southern portions of the continent, where the precipitations are controlled by the "stormy westerlies," southern cyclones, and V-shaped depressions, enjoy very consistent annual totals, but north of the Tropics and in fact in all parts of the continent subject to monsoon rains the departures from the normal are occasionally very great.

When the monsoonal disturbances are in evidence the effect of the rainfall on the country generally and the economic results for the succeeding season are very pronounced. The interior of the continent becomes transformed. The plains, which ordinarily have an intensifying effect on the heat winds of the summer, are deluged with rain and respond immediately with a luxurious growth of grass and herbage. The air is then both tempered in heat and loses its dryness for considerable periods.

The monsoon region comprises the whole of Australia north of the Tropic of Capricorn, together with southern Queensland and the north of New South Wales. The heaviest rains are in January and February. They are directly due to the indraft caused by the heating of the center of the continent. This leads to the formation of a low pressure in northern Australia and the ascending winds are cooled and deposit their water vapor in heavy rainstorms and thundershowers.

Tropical depressions when well developed are productive of good inland rains, and are evidently caused by southward flows of the atmosphere of wide extent and considerable depth. The "Antarctic" disturbances are, however, the more frequent in winter. The heaviest totals from this last-named source are precipitated on the west coast of Tasmania. Thus at Mount Lyell the total for one year exceeded 140 inches, and even the average is 116.05 inches. When an "Antarctic" is supplemented by a "trough" extending well into the northern interior, it brings much rain to the inland areas of South Australia, Victoria, New South Wales, and even Queensland.

Anticyclonic rains occur at all times of the year, but more markedly from March to September. They benefit particularly the southern area of the continent, and are responsible for many of the heaviest rainfalls and floods on the coastal districts of New South Wales.

Flood rains occur at infrequent intervals over various portions of the Commonwealth, principally in Queensland, the southeastern parts of the continent, and the northern regions of West Australia. Typical instances of floods in southeastern Australia are (1) the flood of January, 1910, in the Upper Darling tributaries, consequent on abnormally heavy rains on the northwestern plains and slopes of New South Wales as well as on the Darling Downs of Queensland. These exceptionally heavy continuous rains were caused by the joint action of an anticyclonic area over the southern and a monsoonal depression operating in the northern half of the continent. A monsoonal tongue developed and extended southward over Queensland and New South Wales, while at the same time the energy of the high pressure in the south increased. In five days large areas in the two States had from 5 to 19 inches of rain. The enormous amount of water that fell over approximately 86,000 square miles of country may be roughly estimated at 31,687,000,000 tons, or 7,100,000,000,000 gallons. (2) A similar development occurred in March of the present year [1914], when a monsoonal tongue extending southward across the continent against an intensified anticyclone in the south was accompanied by severe thunderstorms and torrential rains. Some of the heaviest individual falls were in New South Wales, e. g.:

	Inches.
Taralga, on the central table-land	10.74
Sydney	8.49
Parramatta	16.91
Beecraft, in the metropolitan area	18.84
Wollongong, south coast	25.34

The barometer readings at Sydney ranged from 30.13 to 29.97 inches during the five days the storms were in progress, while the anticyclone to the south gradually gave way simultaneously, the center (30.4 inches) moving slowly over the southern parts of Victoria and Tasmania eastward to the South Pacific Ocean.

The wettest known place in Australia is Innisfail, on the northeast coast of Queensland, where the average rainfall for 21 years is no less than 145 inches, the maximum yearly total being 211.24 inches and the minimum 69.87 inches.

The driest region so far furnished with raingages lies east and northeast of Lake Eyre (South Australia), where less than 5 inches is the average annual rainfall, and where a total of 10 inches is rarely recorded during the 12 months. This minimum rainfall is coincident with the lowest elevation, Lake Eyre being actually below sea level 39 feet.

The inland districts of western Australia have, until recent years, been regarded as the driest part of the Commonwealth; but authentic observations taken during the past decade at settled districts in the east of that State show that the annual average is 10 to 12 inches.

In comparing the rainfall of the chief cities of the rest of the world [42 enumerated] with those of Australia, it is found that Bombay, Calcutta, Colombo, Singapore, and Hongkong are the only cities whose rainfall exceeds that of Sydney. Perth has a greater annual rainfall than New York, and more than that of the 42 cities used in the comparison. Hobart nearly equals London, which Melbourne exceeds by an inch, while 11 of the 42 places considered have less rain than Hobart.

The distribution of average annual rainfall over the Commonwealth and the United Kingdom is as follows:

Rainfall is—	Australia.	British Isles.
	Sq. miles.	*Sq. miles.*
Under 10 inches, upon	1,045,000	Nil.
10 to 15 inches, upon	652,000	Nil.
15 to 20 inches, upon	416,000	Nil.
20 to 30 inches, upon	503,000	24,000
30 to 40 inches, upon	199,000	42,000
Over 40 inches, upon	160,000	55,000

The average area under wheat in the United Kingdom during the years 1910, 1911, and 1912, was 1,926,040 acres, and the average yield was 59,436,392 bushels; while in the Commonwealth for the same period the area under wheat was 7,379,980 acres and the average yield 86,243,133 bushels, a difference in the total yield in favor of Australia of 26,806,741 bushels. In Australia wheat growing, under ordinary conditions, is generally considered a safe and payable proposition when 10 inches of rain and over falls from the month of April to that of October, inclusive. There are in all 484,330 square miles of country with 10 inches of rainfall and over during the wheat-growing period. The output of wheat has been steadily increasing from year to year, and there are vast possibilities of future development in this direction.

The climatic history and prosperity of the last 10 years or so contradict emphatically the preconceived notion that Australia is the particular drought-stricken and precarious area of the earth's surface. These misconceptions of the true character of the country have been held in the developmental stages, to a greater or less extent, in the early histories in the majority of all lands and in the colonization of newly discovered territories; e. g., see history of colonization of United States of America and early Egyptian history. The truth of the matter about Australia's rainfall is that—

(1) It is generally ample for pastoral and agricultural industries over two-thirds of its area.

(2) That different regions have distinct wet and dry periods; these must be fully recognized and industrial operations adapted accordingly.

(3) It is subject in part, but never in the whole, to prolonged periods when the rainfall is short of the seasonal average. Australia is not peculiar in this respect.

It follows, therefore, that, as the so far undeveloped country becomes populated and put to profitable use, the general wealth of the community as a whole will steadily increase.

A model representing the relative rainfall over Australia has been constructed at the Commonwealth Weather Bureau, on a horizontal scale of 133 miles to 1 inch and a vertical scale of 10 inches to 1 centimeter. This model shows at a glance how the annual rainfall is distributed, from the small precipitation over the far interior to the fringe of high rainfall around the greater portion of the coast line, culminating on the eastern side in a great "peak" indicating the annual precipitation over the Harvey Creek and Innisfail district resulting from the prevailing southeast trade winds carrying the moisture against the mountain ranges just inside the coast.

The fringe of relatively high rainfall along the eastern and southeastern coasts of the continent as the result of the elevated contours near the coast in those regions is also striking. The effect of the monsoonal rains over northern Australia is very apparent from the model, which shows the gradual increase of rainfall from less than 10 inches in the interior to over 60 inches on the north coast.

The manner in which the prevailing westerly trade winds carry moisture along the southerly portion of the Commonwealth is clearly marked by the elevations indicating the good rains received over the southwest corner of Australia, and further eastward how the ranges east of Adelaide cause good rainfall there and prevent the rain from that direction reaching the inland parts of Victoria.

In Tasmania, also, is seen the effect of the frequency of the moist westerly winds, causing high rainfall along the mountain ranges of the west coast, with resulting comparative dryness in the eastern parts of that State.

It may be of interest to note in closing that there exists apparently an oscillatory movement of the seasonal rains throughout Australia, about a center in the vicinity of Forbes, New South Wales. It is perhaps a natural coincidence that this apparent center of oscillation is approximately the center of gravity of the Commonwealth's population and is not far from the Federal capital site.

This peculiar oscillatory character of the monthly march of rainfall suggested the construction of a "rain clock." In the center of a piece of cardboard a map of Australia is cut out with a die. At the back of this another piece of cardboard representing the rain area is manipulated on a swivel. By moving the second piece of cardboard backward and forward with an amplitude of oscillation of one-fifth of a circle (72° arc) the land area of the continent affected by dry or wet conditions at any time of year is approximately indicated.

The immediate lessons to be learned from a study of this "clock" are that the seasonal rains are more regular than was generally believed, and that the alternating dry and wet seasons are definitely defined. That being so, when, in obedience to physical law, there is an absence of rain during the normally dry period in any part of Australia, such dryness should not be regarded as drought and an evil, but rather as nature's wise provision for resting the soil.

INFLUENCE OF WEATHER CONDITIONS ON THE AMOUNTS OF NITRIC ACID AND OF NITROUS ACID IN THE RAINFALL NEAR MELBOURNE, AUSTRALIA.[1]

By V. G. ANDERSON.

Daily determinations of the amounts of nitric and of nitrous acid in the rainfall at Canterbury, near Melbourne, have been made since November 1, 1912. The results to February 28, 1914, when correlated with meteorological data for Melbourne and daily isobaric charts of Australia, reveal the existence of a relation between weather conditions and the amounts of nitrogen acids in rain water.

The concentration of nitric acid reached a maximum in summer, a minimum in winter, and an intermediate position during autumn and spring.

The concentration of nitrous acid reached a maximum in winter and a minimum in summer. The ratio of nitric nitrogen to nitreous nitrogen was highest in summer and lowest in winter. On many occasions during winter the ratio was approximately 1:1. A relation between atmospheric temperature and this ratio was noted. Its nature was shown by plotting the mean minimum temperature each month with the mean monthly ratios, the curve being of the same type as those which express changes of chemical velocity with temperature. The ratio is doubled for equal increments of temperature. From the results it would appear that in rain water nitric and nitrous acids are formed in equal molecular proportions and that, if the ratio could be determined instantly or before any change could ensue, it would invariably be 1:1. In cold weather the velocity is retarded to such an extent that little change occurs even after comparatively long periods; hence the increased amounts of nitrous acid found in winter. In hot weather the velocity being greatly increased, the residual amounts of nitrous acid are very small, nearly all having been converted into nitric acid.

The facts point to atmospheric nitrogen peroxide as the source of nitric and nitrous acids in rain water, as

[1] *Reprinted from* Report of the Eighty-fourth Meeting, B. A. A. S., Australia, 1914. London, 1915, pp. 338-339.